A Short Dictionary of Remote Sensing Terms

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Let's look at 3 kinds of properties that are important to understand about aerosols

Physical Properties

Optical Properties

Chemical Properties

These two types of properties are very closely linked in remote sensing because we infer the Physical properties from Optical measurements

Because we measure the entire column our properties represent the mean particle characteristics.

Physical Properties

Aerosol Amount

- AOD - Aerosol Optical Depth
- AOT - Aerosol Optical Thickness

These optical measurements of light extinction are used to represent aerosol amount in the entire column of the atmosphere.

Optical Depth and Optical Thickness

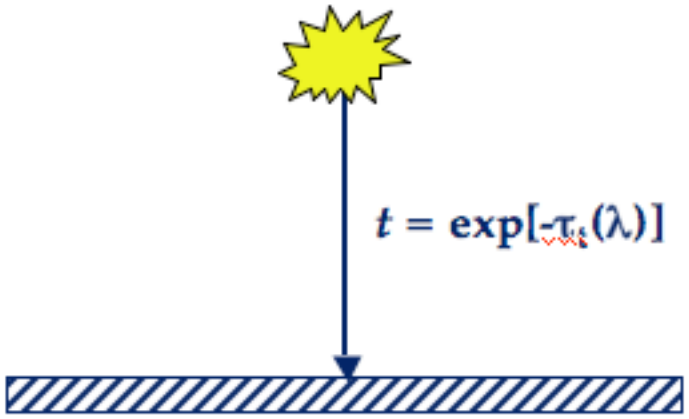
- Optical depth (τ)
  - Total attenuation along a path length, generally a function of wavelength [dimensionless]

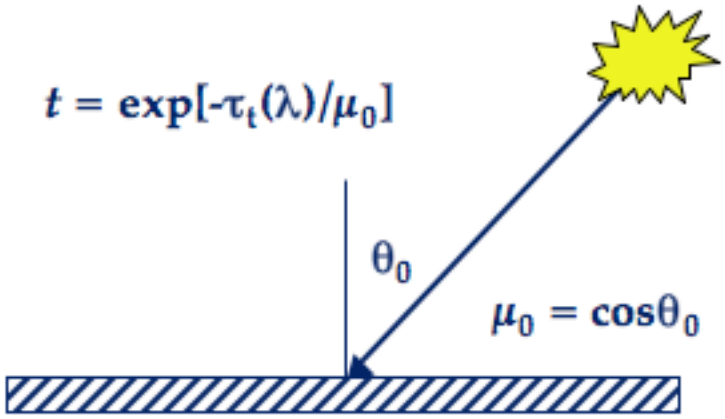
$$\tau(\lambda) = \int_0^X \sigma_{ext} dx$$

- Total optical thickness of the atmosphere (τ_t)
  - Total attenuation in a vertical path from the top of the atmosphere down to the surface

$$\tau_t(\lambda) = \int_0^\infty \sigma_{ext} dz$$

- Transmission of the direct solar beam





Physical Properties

Aerosol Amount - AOT, AOT

- Aerosol Mass Concentration - Mass / cm^2 (MODIS Units)

- $PM_{2.5}$ - particles of less than 2.5 μm aerodynamic diameter
  These can penetrate deeply into the lungs

$\therefore$ $PM_{2.5}$ concentration at ground level is an important parameter for air quality studies.

- CCN (Cloud Condensation Nuclei) Concentration.

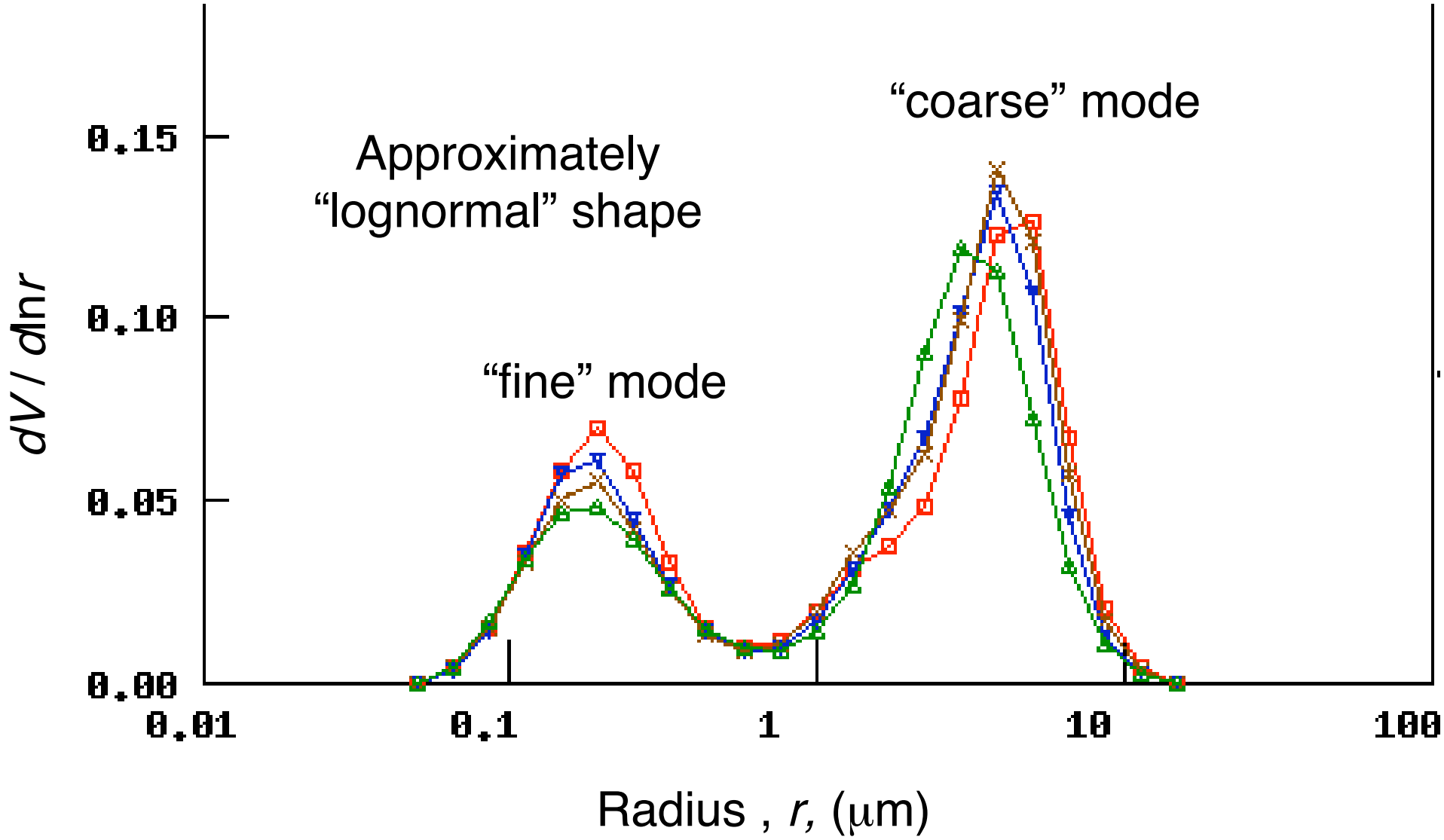
These are particles that act as condensation surfaces and encourage water droplet formation within clouds.

Physical Properties

Particle Size Distribution - There is an assumption, based on many years of measurements, that aerosols in the optically active size ranges are best represented as a bimodal distribution. The aerosol size distribution can be represented as a volume or number distribution.

The mode representing the small (fine mode) aerosol has a size distribution centered on radii between 0.1 and 0.25 microns.
The mode representing the large (coarse mode) aerosol has a size distribution centered on radii between 1 and 2.5 microns.

Size Distribution



Physical Properties

Angstrom Exponent

The Angstrom exponent is often used as a qualitative indicator of aerosol particle size, with values greater than 2 indicating small particles associated with combustion byproducts, and values less than 1 indicating large particles like sea salt and dust.

For measurements of optical thickness

$\tau_{\lambda 1}$ and $\tau_{\lambda 2}$ taken at two different wavelengths λ_1 and λ_{21}

$$\alpha = -\frac{\ln \frac{\tau_{\lambda_1}}{\tau_{\lambda_2}}}{\ln \frac{\lambda_1}{\lambda_2}}$$

Physical Properties

Particle shape - spherical, spheroid, non-spherical

Optical Properties

Light Scattering
Light Absorption $>$ These quantities are difficult to separate and measure individually

Extinction = Scattering + Absorption

Single Scattering Albedo - a measure of how absorbing or scattering we consider the mass of aerosol particles.

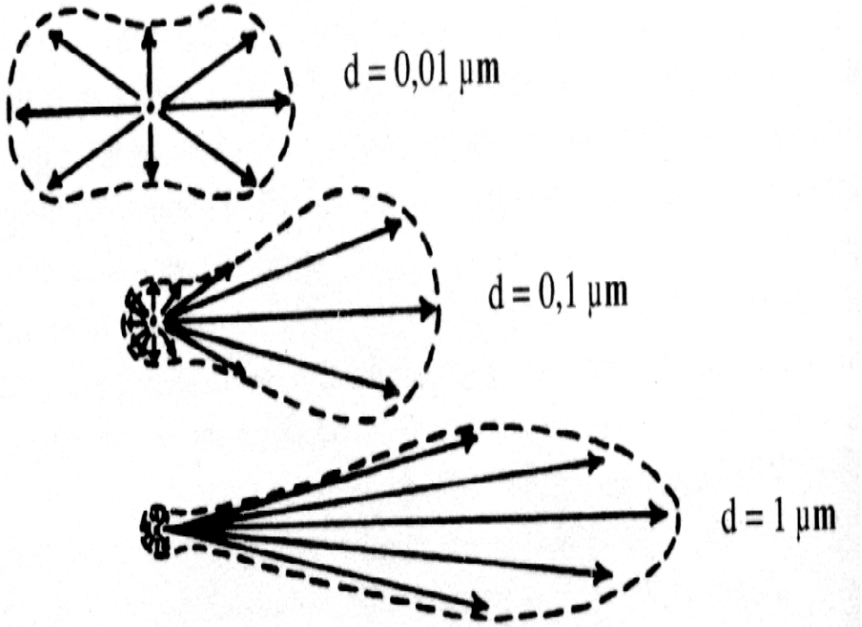
$$\omega_o = \frac{\text{AOTscatter}}{\text{AOTscatter} + \text{AOTabsorption}}$$

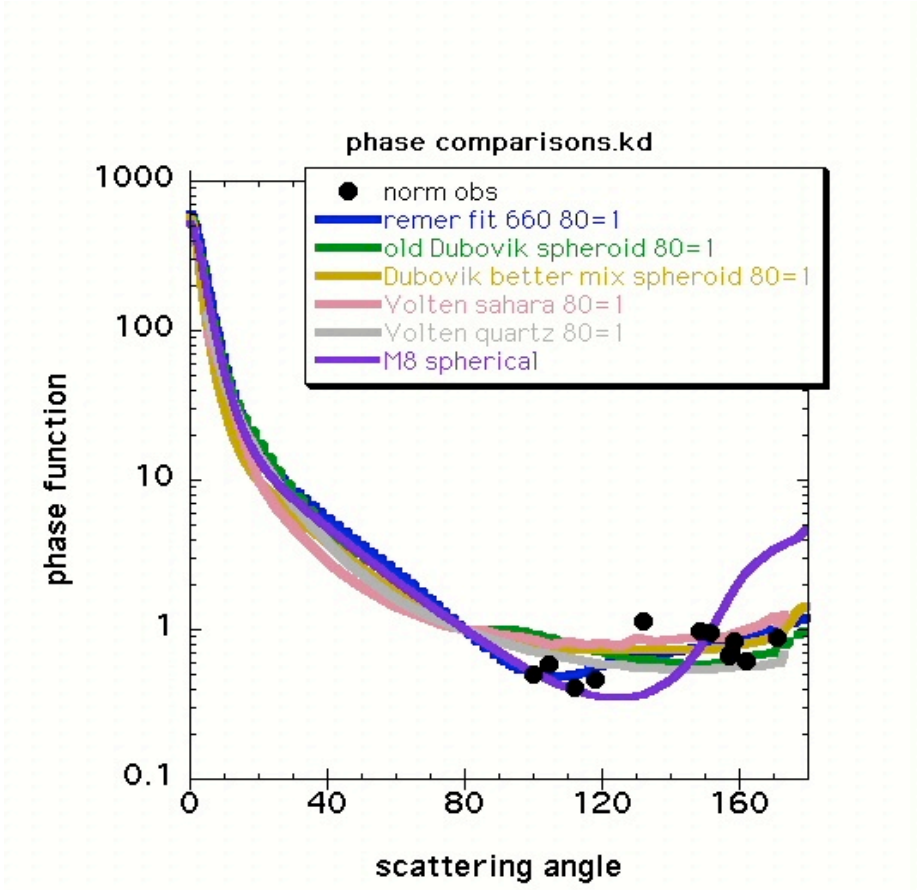
Values of .85 are considered very absorbing
Values of .95 are considered very non-absorbing

Optical Properties

Scattering Phase Function

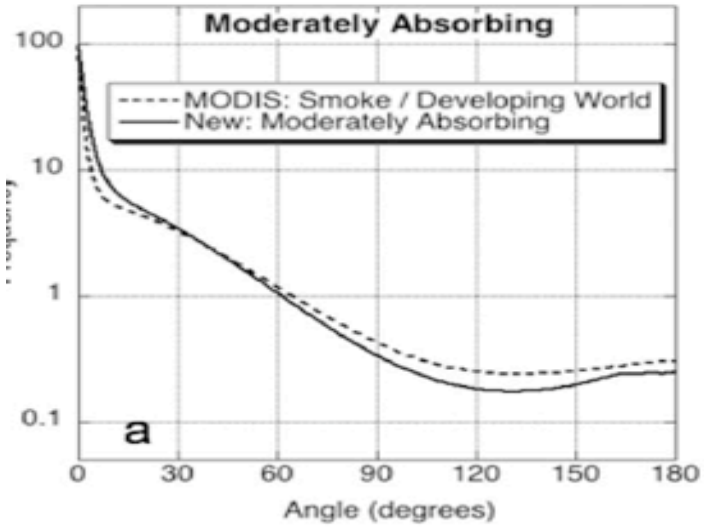
The directional light scattering due to the aerosol particles

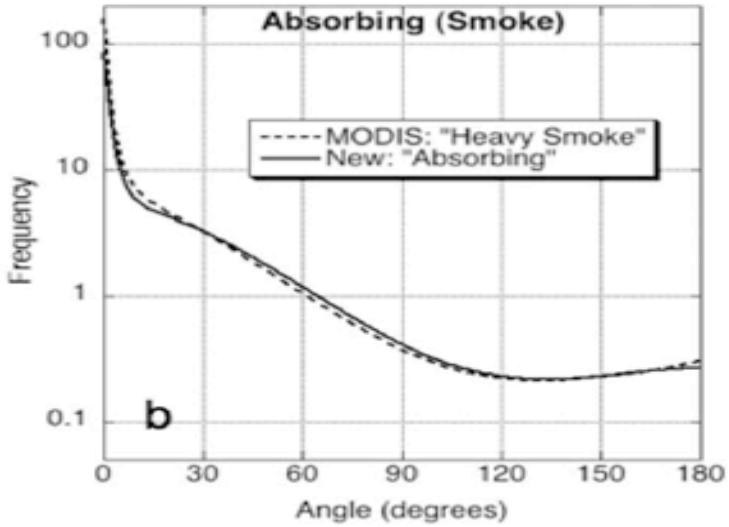


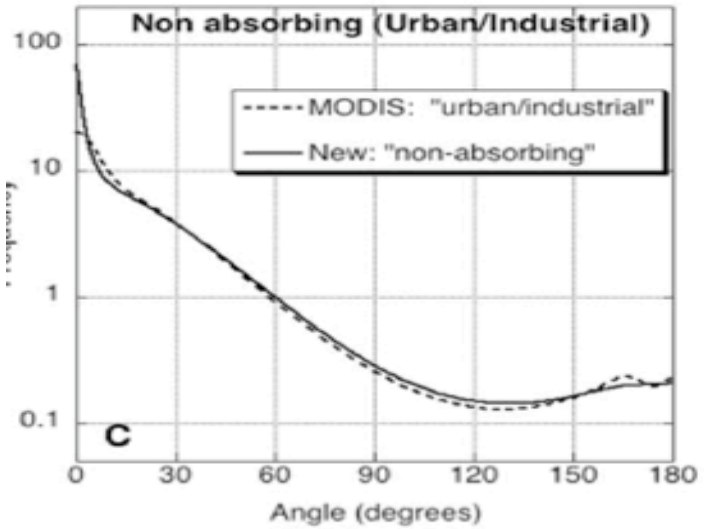


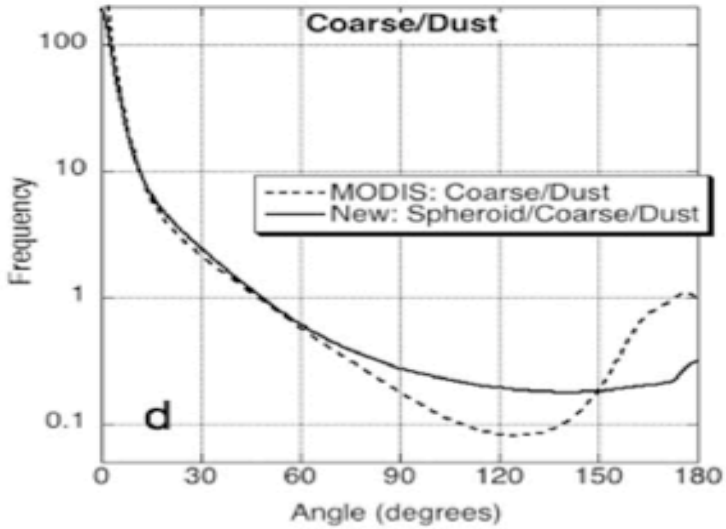
Optical Properties

Sample Phase Functions









Optical Properties

Complex Index of Refraction

Real Component - refers to light bending

Imaginary Component - refers to light absorption due to the material

Radiative Transfer

The physics and mathematics of how radiation passes through a medium that may contain any combination of scatterers, absorbers, and emitters.

Aerosol Inversion

Using the measured optical properties to infer the physical characteristics of the Aerosol.

This is performed by an inversion of the Radiative transfer equations.